USING THE ARC LENGTH APPROACH TO CHECK POSITIONAL STABILITY OF RADIO SOURCES

O. MOLOTAJ(1), L. PETROV(2), D. VOROBJEV(1)

1- Astronomical Observatory of University of Kyiv, Observatorna str. 3, Kyiv, 04053 Ukraine
2- Code 926, NVI, Inc./NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
e-mail: molotaj@observ.univ.kiev.ua pet@leo.gsfc.nasa.gov

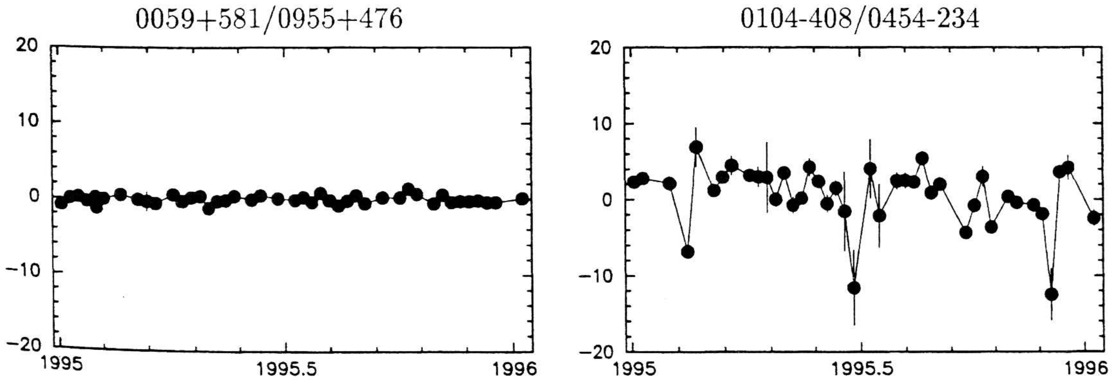
ABSTRACT. The arc length method for investigation of the stability of radio source positions was tested using 50 NEOS-A VLBI sessions from 1995. Twenty stable sources were selected.

In the early 80s when regular VLBI observations of extragalactic sources began, we believed that quasars would not exhibit apparent proper motion since they are located at gigaparsec distances. Later, it was found that all sources have structure at the level of 1-10 nanoradians which in many cases is variable on time scales of years. It was found that some quasars do show non-linear apparent motion at a level exceeding 10 formal errors of the estimates of their coordinates. To our shame, up to now source structure is not taken into account in routine VLBI data analysis. In order to alleviate this problem, we separate sources onto two groups: sources with stable apparent position and sources with unstable position.

We used the arc-length approach in order to classify the source positions stability. First, positions of all sources were obtained from each 24 hour VLBI session independently keeping nutation angle and UT1 fixed to the a priori values. Then we computed arc-lengths using the estimates of source positions and their covariances. Of course, errors in a priori nutation angles and UT1 will add arbitrary rotations to the daily catalogues of source positions but they will not affect arc-lengths which are invariant to rotation.

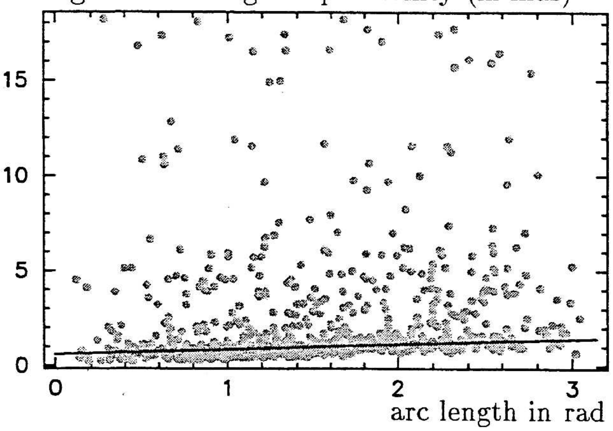
In order to test this approach, a short series of VLBI observations consisting of 50 diurnal sessions of the 1995 NEOS-A observing campaign, with about 50000 observations of 145 radio sources, was analyzed. In each session 26 to 53 different sources were observed, and 12 sources were observed in every experiment. Arc-lengths and their formal uncertainties were obtained for each pair of sources observed in the same session using the estimates of their positions and the time series of arc-lengths were generated. Two examples are shown in fig. 1.

fig. 1: Arc length evolution (in mas)



We computed the average lengths of all arcs over all observations, subtracted these averaged lengths and formed small residuals. The averaged rms of residuals over the entire dataset was about 0.02 mas. Then we computed the averaged rms of residual arc-lengths over all arcs of each session. They ranged between 0.01 and 0.06 mas. It was noticed that these statistics increased for the two sessions in February and for the experiments in September–November.

fig. 2: Arc length repeatability (in mas)



We investigated arc-length repeatability for each arc over the annual data set (fig. 2) which we defined as an unweighted rms of residual arc-lengths. We found that the repeatability depends on the number of observations of the sources which form the arc, the smaller the number of observations, the larger the repeatability. It appeared that the distribution of the arc length repeatability is far from normal: 90% of the points are grouped around the regression line $4.9 \cdot 10^{-9} + 1.3 \cdot 10^{-9} L$ where L is arc-length in radians while there is an excess of arcs with larger repeatability.

In order to select the most stable sources from the full set of 145 sources with about 3000 arcs we used the following procedure. First, all arcs with less than 30 observations were discarded. Then we selected 200 arcs with the lowest repeatability values: the arc which repeatability deviates by no more than 0.5 mas from regression line mentioned above. Then we investigated how frequently each source appeared in the arc which belong to the set of 200 stable arcs. The sources which formed the stable arcs more frequently were put into the group of stable sources.

We found 20 stable sources which satisfy this criteria and list them in Table 1. These source are mainly included in 200 stable arcs. It is notable that these stable sources are distributed over all three ICRF radio source categories: defining, candidate, other.

Table 1: **List of stable radio sources.** ICRF status: D[efining], C[andidate], O[ther]. Sources observed in all 50 sessions are marked by asterisk

IAU name	ICRF status	*	IAU name	ICRF status	*	IAU name	ICRF status	*	IAU name	ICRF status	*
0014+813	D		0727-115	O	*	1228+126	C		1611+343	C	
0059+581	O		0804+499	D		1308+326	D	*	1638+398	O	
0202+149	C		0923+392	O		1334-127	O	*	1745+624	D	
0552+398	C	*	1128+385	D		1357+769	C		1749+096	C	*
0642+449	D		1219+044	D	*	1606+106	D	*	2145+067	D	*